

SENSOR SOLUTIONS

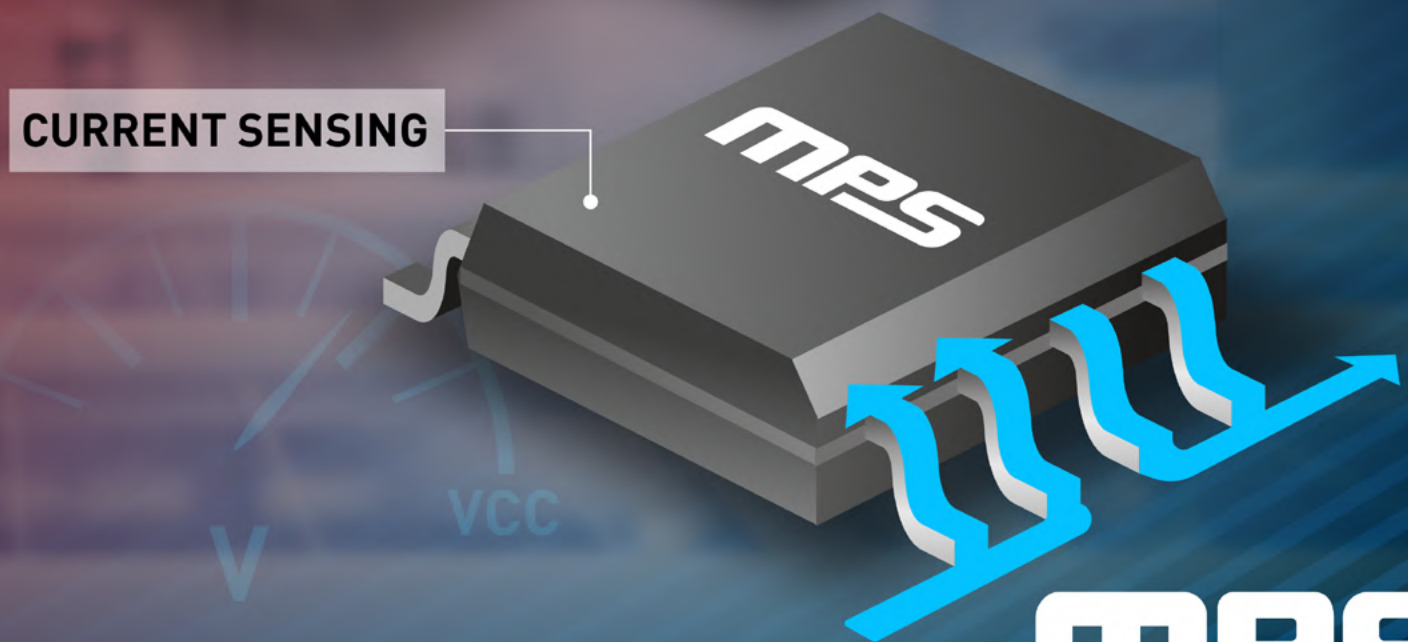
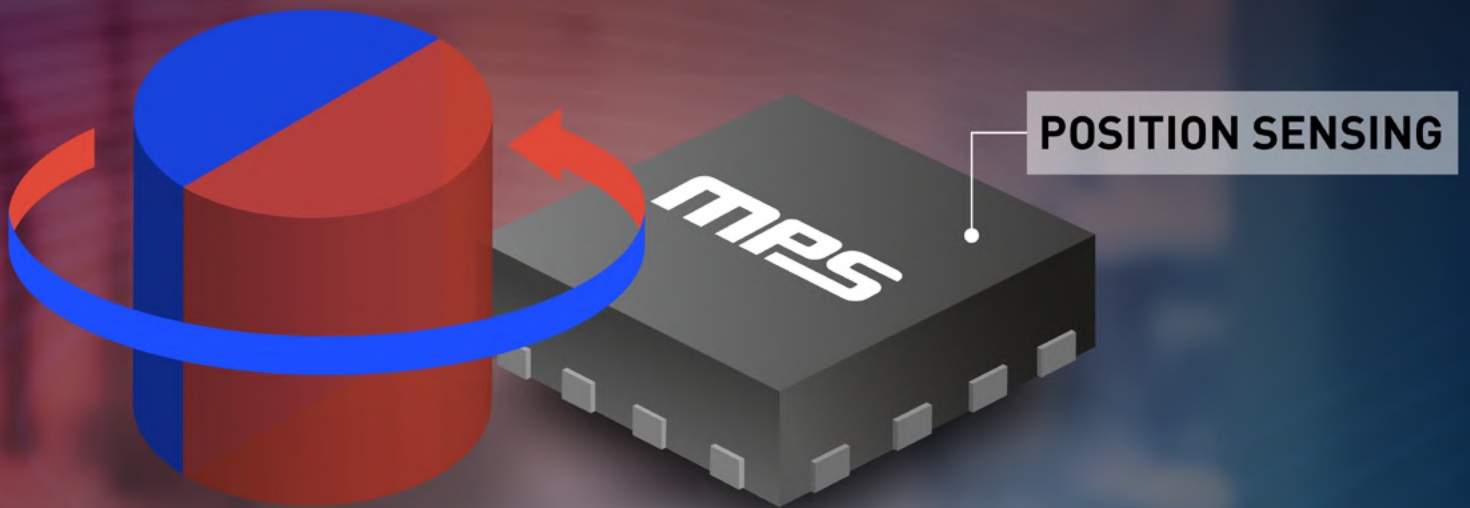
Designed for Applications In:

» AUTOMOTIVE

» INDUSTRIAL

» MEDICAL

» CONSUMER



MPS
MonolithicPower.com

Quality Assurance & Reliability Commitment

The MPS Quality Assurance organization develops, coordinates, and champions strategic quality initiatives throughout MPS Inc., its foundries, and sub-contractors. Its mission is to enable MPS to design, develop, manufacture, and deliver products to our customers with world-class quality and reliability that meet and exceed our customers' expectations.

MPS and Its Supplier Quality Systems and Certificates:

- ISO9001:2008 (MPS)
- EU RoHS/HF/REACH Compliant (MPS)
- Sony Green Partner (MPS & Suppliers)
- TS16949 (Suppliers)
- ISO14001 (Suppliers)

Product Quality:

- Automotive Products Qualified per AEC-Q100 Standard
- Standard Products Qualified per JEDEC and Military Standards
- Reliability Failure Rate <10FIT
- Product Quality Level <1.0ppm

Quality Control and Monitoring:

- On-Site Foundry and Assembly Teams for Real-Time Actions
- Quarterly Supplier Quality Review and Annual Supplier Audit
- Short-Term Reliability Monitor Test – Daily
- Long-Term Reliability Monitor Test – Monthly
- Real-Time Engineering Actions on Monitor Failure
- Quarterly Reliability Monitor Reports



In This Guide

Product Overview

MagAlpha Position Sensors	4
Current Sensors	5

Automotive

Sensors for Motor Position/Speed Control and Current Sensors	6
Body Electronics	8
Power Management	8
Thermal Management	9
Interior Cabin Control and Car Audio	9
Power Steering	10
Automotive Product Selector Guide	11

Industrial Building & Factory Automation

Safety & Security	12
Power Management	13
Thermal Management	13
Climate & Energy Efficiency	14
Industrial Automation	15

Medical Technology

Lab Automation	16
Surgical Robotics	17
Automated Motorized Equipment	18

Consumer Products

Mobile Phones & Laptop Computers	19
Battery-Powered Hand Tools	20
E-Bikes & Scooters	21

Comprehensive Product Selector Guide

Current Sensors	22
Position Sensor Magnets	22
MagAlpha Series	23

Contact & Ordering

About Monolithic Power Systems	24
Locations	25

MagAlpha Position Sensors

Advantages of MagAlpha Angle Sensors:

- » Instantaneous, Absolute Angle Sensing
- » High Resolution
- » Low INL as Low as 0.5° over Temp and Reflow
- » High Bandwidth Up to 27kHz
- » Factory Calibration Eliminates In-System Calibration
- » Ideal for Battery-Powered Applications: $<0.5\mu\text{A}$ Idle Current
- » Smallest Footprint: QFN-14 (2mmx2mmx0.6mm)
- » Flexible Sensor Location: End-of-Shaft or Side-Shaft

MagAlpha sensors utilize an array of Hall plates that are sampled successively at very high speeds in such a way that the signal phase represents the angle to be measured. The “phase-to-digital” SpinAxis™ technique captures the angle instantaneously every $1\mu\text{s}$ without the need for A-to-D conversion or arc tangent calculation. This means that the sensor is able to work over a wider magnetic field range (typically 30mT to 150mT), giving greater flexibility and tolerance for magnet positioning.

The fast Hall sampling and subsequent digital conditioning result in very low latency, from Hall array sampling to the data availability at the sensor output. Typical latency is between $1\mu\text{s}$ to $8\mu\text{s}$ at a constant rotation speed, depending on the part number, allowing MagAlpha sensors to operate in systems with high rotation speed or that require fast position control loops. Rotation speeds from 0rpm to more than 100,000rpm are possible.

Side-Shaft Capability

MagAlpha sensors support both end-of-shaft and side-of-shaft topologies. In end-of-shaft, the sensor is placed directly below the magnet connected to the rotating shaft. This topology offers the best performance, but is not always mechanically convenient because the end of a rotating shaft may not be accessible. For example, in a motor, it may be hidden by the shaft bearing, or driving into a gearbox.

Side-shaft topology allows the magnet to be placed to the side of a ring magnet, mounted on the rotating shaft. This is advantageous for many designs as the ring can be located anywhere on the shaft, which allows the sensor to be embedded more easily within the motor or product casing. MagAlpha sensors include dedicated bias trimming registers for side-shaft applications. When the sensor is placed in a side-shaft configuration, the unique bias trimming enables the sensor to measure irregular magnetic fields and output a linear response across the full angle range without in-system calibration (see Figure 1).

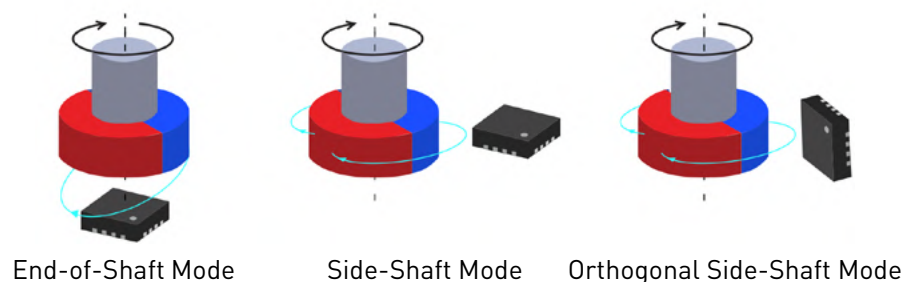
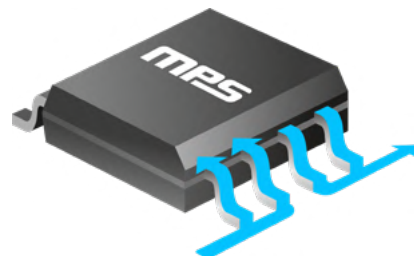


Figure 1: Magnet and Sensor Positioning

Current Sensors

Advantages of MPS Current Sensors:

- » Complete Isolated Current Sensor in a Small SOIC-8 (5mmx6.2mm) Package
- » Single IC Is Simple and Cost Effective to Design In
- » Smallest Solution Footprint
- » Wide Current-Sensing Range from $\pm 5\text{A}$ to $\pm 50\text{A}$, AC or DC
- » Low Conductor Resistance for Low Power Loss: $0.9\text{m}\Omega$
- » $\pm 2.5\%$ Accuracy over Temp, Factory-Trimmed
- » Immune to Stray Magnetic Fields via Differential Sensing
- » No Magnetic Hysteresis



MPS current sensors integrate galvanic isolation, high-voltage continuous operation, and high-current sensing into a small, industry-standard SOIC-8 package. Our current sensors utilize an array of differential, linear Hall sensors that pick up the target induced magnetic field from the primary conductor while rejecting unwanted stray fields. This makes our current sensors ideal for use in magnetically noisy environments. In addition, the low resistance of the integrated conductor results in improved efficiency and reduced power loss compared to a shunt resistor alternative.

The low-resistance primary conductor allows current to flow near the sensor IC. The current generates a magnetic field, which is sensed at two different points by the integrated Hall sensors. The magnetic field difference between these two points is converted into a ratiometric voltage proportional to the applied current (see **Figure 2**). A unique spinning current technique provides a low offset that remains stable across a wide temperature range.

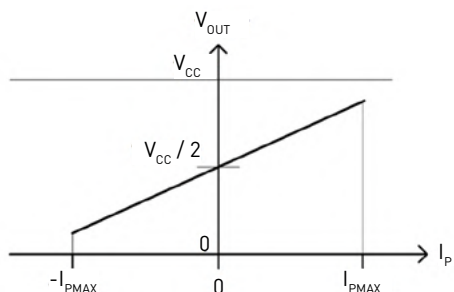


Figure 2: Output Voltage Proportional to Primary Current

The primary conducting leads are electrically isolated from the sensor leads on the secondary side, producing a sensor with a high isolation voltage and working voltage (see **Figure 3**). This makes our current sensors ideal for high-side current sensing without the need for expensive, large-footprint optical or inductive isolation alternatives.

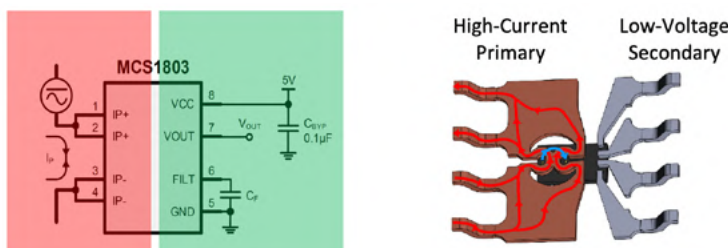
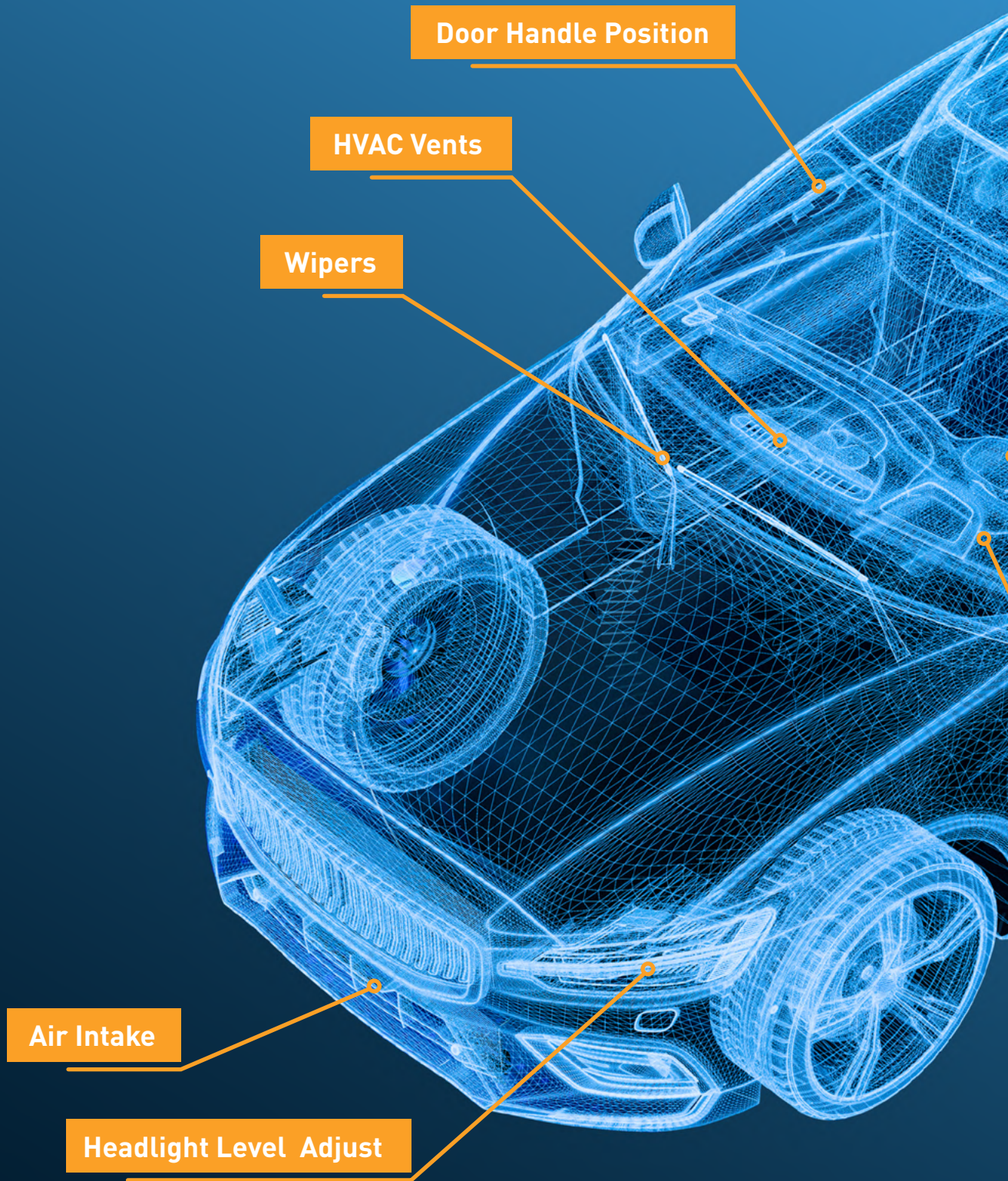
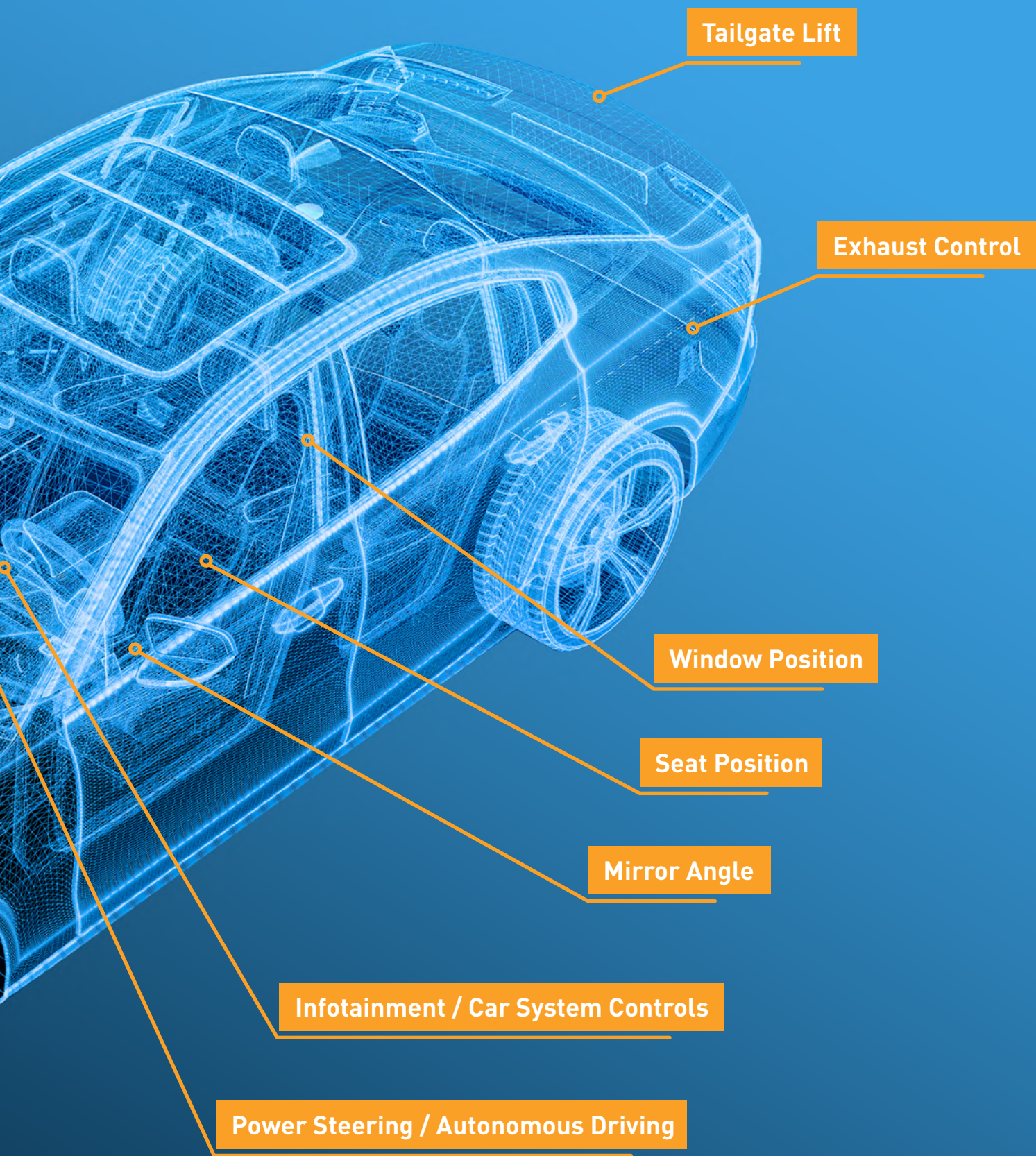


Figure 3: High-Voltage Isolation in Standard SOIC Package

Sensors for Motor Position/Speed Control and Current Sensors





Tailgate Lift

Exhaust Control

Window Position

Seat Position

Mirror Angle

Infotainment / Car System Controls

Power Steering / Autonomous Driving

Body Electronics



- » Retracting Door Handles
- » Tailgate Lifters
- » Suspension Sensors
- » Wiper Motors
- » Spoiler Actuation

Power Management



- » Precision, High-Current Sensing and Control:
 - Wallbox Chargers
 - Qi Chargers
 - Power Monitoring Systems

Thermal Management



- » Fluid Pumps
- » Air-Grill Shutters
- » Cooling Fan Modules

Interior Cabin Control and Car Audio



- » Contactless Infotainment Consoles
- » Audio Amplifier Current Sensing
- » Contactless Gearshift Control
- » Seat Position Motors Control
- » Sunroof Motor Control

Power Steering

Product Highlight

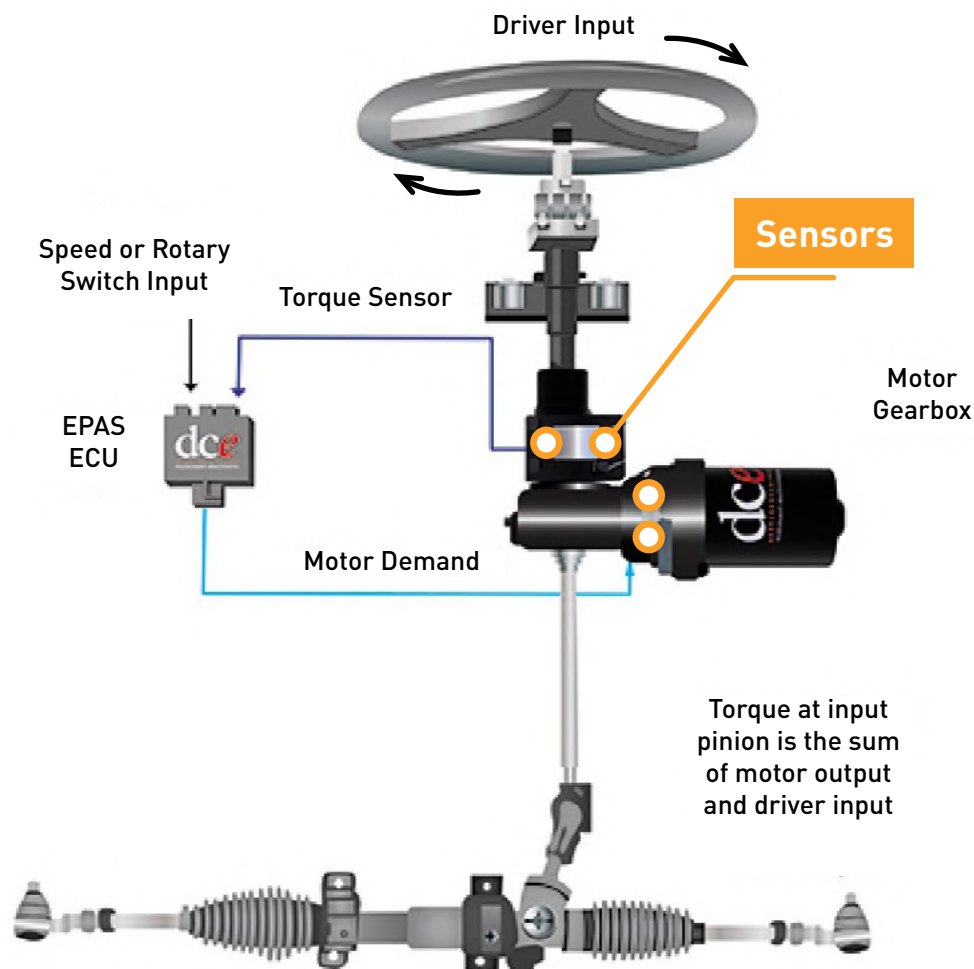
Replace Optical Sensors in Automotive Power-Assisted Steering (PAS)

MAQ430

- » Motion Control and Position Sensing
- » Cost-Effective, Contactless Alternative to Optical Sensing
- » AEC-Q100 Grade 1 Qualified
- » ASIL-D by Software Free Sensor Solution
- » Wide Operating Temperature Range: -40°C to +150°C

Simple to Use:

- » No Calibration
- » Simple Field Diagnostics
 - Magnet Presence and Distance Detection



AUTOMOTIVE PRODUCT SELECTOR GUIDE

POSITION SENSORS

Part Number	Supply Voltage	Supply Current (mA)	Resolution	Output Format	ABZ Resolution (Bits)	PWM Frequency (Hz)	Latency (µs)	Start-Up Time (ms)	Refresh Rate (kHz)	Filter Cutoff Frequency (kHz)	Magnetic Field Frequency (Hz)	Temperature Range (°C)	Wettable Flank QFN Option	Package	Notes
N MAQ430-AEC1	3.3V	11.7	12-bit	SPI, ABZ, UVW	10	-	8	12	980	390	✓	-40 to +150	✓	QFN-16 (3x3)	Supports end-of-shaft, side-shaft topologies
N MAQ470-AEC1	3.3V	11.7	12-bit	SPI, SSI, ABZ, PWM	10	240	8	12	980	390	✓	-40 to +150	✓	QFN-16 (3x3)	Supports end-of-shaft, side-shaft topologies
N MAQ473-AEC1	3.3V	11.7	14-bit	SPI, SSI, ABZ, PWM	12	970	8	0.6/12/260	980	23 to 6k	✓	-40 to +150	✓	QFN-16 (3x3)	Supports end-of-shaft, side-shaft topologies

CURRENT SENSORS

Part Number	Supply Voltage	Supply Current (mA)	Current Range (A)	Output Format	Accuracy % (25°C to 125°C)	Bandwidth (kHz)	Response Time (µs)	Temperature Range (°C)	Start-Up Time (µs) FILT Unconnected	Primary Conductor Resistance (mΩ)	Package	Notes
S MCQ1802-xx-AEC	3.3V	8.5	±5, ±10, ±20, ±30, ±40, ±50	Analog, Ratiometric	2.5	100	5	-40 to +150	90	0.9	SOIC-8	Coreless, analog output, immune to ext. magnetic fields
S MCQ1803-xx-AEC	5V	8.5	±5, ±10, ±20, ±30, ±40, ±50	Analog, Ratiometric	2.5	100	5	-40 to +150	90	0.9	SOIC-8	Coreless, analog output, immune to ext. magnetic fields

N - New Product **S** - Sampling Product

INDUSTRIAL BUILDING & FACTORY AUTOMATION



Safety & Security



- » Access Control
- » Automated Doors
- » Smart Door Locks
- » Elevators and Escalators
- » Fire Prevention

Power Management



- » Solar Inverters
- » Power Monitoring
- » Power Access
- » Light Monitoring

Thermal Management



- » Cooling
- » Fluid Pumps
- » Valve Control

Climate & Energy Efficiency



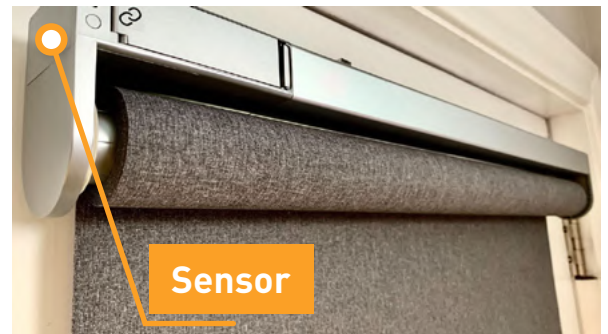
- » Shutters and Blinds
- » HVAC – Compressors, Blowers, Flow Control
- » Climate Control – Thermostat

Product Highlight

Smart Shades

MA732, MA330

- » Motor Commutation and/or Position Feedback
- » Provides Absolute Feedback
- » Operates with a Low-Cost Magnet
- » Works with All Types of Motors



Industrial Automation



Product Highlight

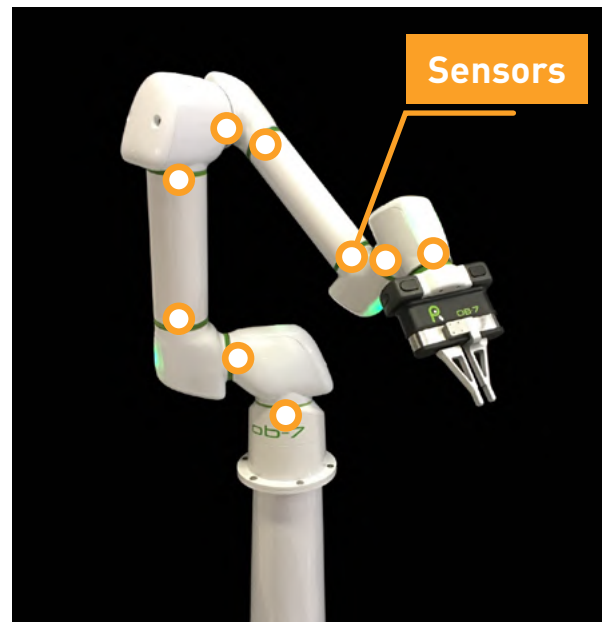
Precision Robotic Joint Control

MA600

- » 0.5° INL over Temp after PCB Reflow
- » 11-Bit to 14-Bit Low Latency Resolution
- » 27kHz Bandwidth
- » Latency as Low as 1 μ s
- » No Calibration Required

Cost-Effective Solution for Managing:

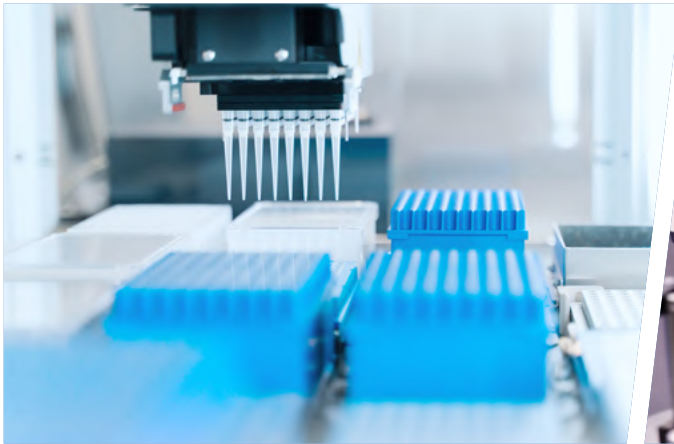
- » High-Speed Torque
- » Position
- » Speed Control



MEDICAL TECHNOLOGY



Lab Automation



- » Robot Control
- » Probe Processing
- » Pump Motor Control

Surgical Robotics



- » Automated and Remote Surgical Robots
- » Dental Processing

Product Highlight

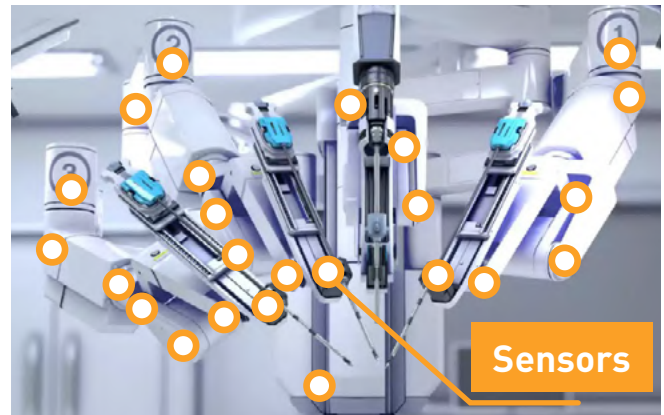
Surgical Robotics

MA600

- » 0.5° INL over Temp after PCB Reflow
- » 11-Bit to 14-Bit Low Latency Resolution
- » 27kHz Bandwidth
- » Latency as Low as 1 μ s
- » No Calibration Required

Cost-Effective Solution for Managing:

- » High-Speed Torque
- » Position
- » Speed Control



Automated Motorized Equipment



- » Ventilators and Respirators
- » Insulin and Fluid Pumps
- » Medical Beds

Product Highlight

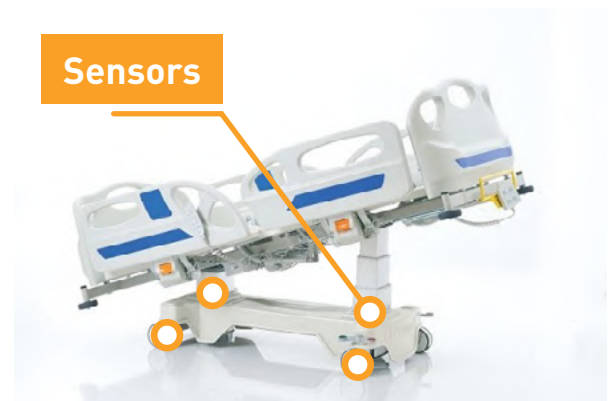
Hospital Beds

MA732

- » Hospital Bed Comfort Controls and Locomotion Assist Motors
- » Absolute Position Feedback Control
- » 14-Bit Resolution

Flexible Interface:

- » SPI for Digital Angle Readout and Configuration
- » Incremental 12-Bit ABZ Quad Encoder with Programmable PPT from 1 to 1024
- » 14-Bit PWM



CONSUMER PRODUCTS



Mobile Phones & Laptop Computers



- » Foldable Mobile Flip-Phone Angle Management
- » Foldable Tablet Angle Sensing
- » Precision Open/Close Angle Management

Product Highlight

No-Bezel Laptops and Foldable Phones

MA782

- » Smallest Open/Close Detection Solution
- » Helps Minimize or Eliminate Bezel
- » Can Be Placed in the Folding Axis
- » Smallest QFN (2mmx2mm) Package
- » Lowest Power: 0.5µA Standby Current
- » Wake-on-Change Angle Detection
- » Very Small (<1mmx1mm) Magnet
- » Provides Absolute Angle Output



Battery-Powered Hand Tools

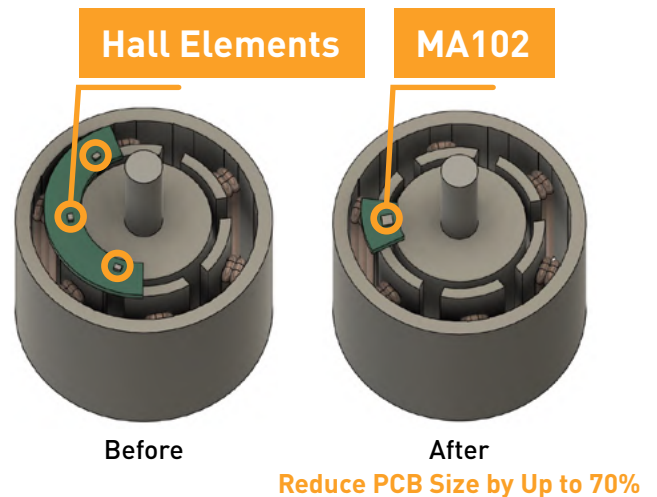


Product Highlight

Power Tool BLDC Motor: Replace 3 Hall Switches with 1 MagAlpha

MA102

- » Eliminate Mechanical Alignment with Stator
- » Better Phase Alignment = Higher Torque and Improved Efficiency
- » Reduce Part Count by Up to 70%
- » Reduce PCB Size by Up to 70%
- » Increase Mechanical Flexibility
- » UVW Output Means No Firmware Change
- » Wide -40°C to +125°C Operating Temp Range



E-Bikes & Scooters



- » BLDC Motors – Smaller, Lighter, Increased Reliability
- » Enables Highest Power Density
- » Provides Absolute Angle, Position, and Torque

Flexible Interface:

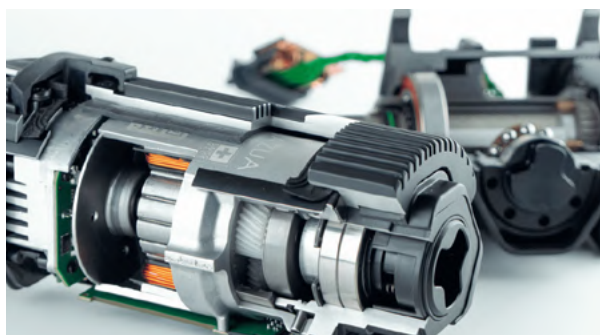
- » SPI Commutation for UVW Commutation
- » ABZ Speed Control

Product Highlight

E-Bike Ultra-Small BLDC Motors

MA302

- » Control Speed, Torque, and Absolute Position
- » Smallest QFN (3mmx3mm) Package
- » No Customer Calibration Required
- » Factory Calibrated
- » On-Chip Non-Volatile Memory (NVM)
- » Wide -40°C to +125°C Operating Temp Range
- » Flexible Interface
 - SPI for Digital Angle Readout and Sensor Configuration
 - ABZ/UVW for Motor Control, Commutation, and Incremental Output
 - No FW Changes Required when Replacing Optical Encoders. ABZ Output is Compatible with Optical Outputs



COMPREHENSIVE PRODUCT SELECTOR GUIDE

CURRENT SENSORS

Part Number	Current Range (A)	Supply Voltage	Accuracy (from 25°C to 125°C)	Temperature Range (°C)	Bandwidth (kHz)	Isolation Voltage (V)	Primary Conductor Resistance (mΩ)	Package	Notes
N MCS1800	±12.5, ±25	3.3V	3%	-40 to +125	100	1000	1.2	SOIC-8	Coreless, analog output, immune to external magnetic fields
N MCS1801	±12.5, ±25	5V	3%	-40 to +125	100	1000	1.2	SOIC-8	Coreless, analog output, immune to external magnetic fields
N MCS1802	±5, ±10, ±20, ±30, ±40, ±50	3.3V	2.5%	-40 to +125	100	2200	0.9	SOIC-8	Coreless, analog output, immune to external magnetic fields
N MCS1803	±5, ±10, ±20, ±30, ±40, ±50	5V	2.5%	-40 to +125	100	2200	0.9	SOIC-8	Coreless, analog output, immune to external magnetic fields
S MCQ1802 -AEC1	±5, ±10, ±20, ±30, ±40, ±50	3.3V	2.5%	-40 to +150	100	2200	0.9	SOIC-8	AEC-Q100, coreless, analog output, immune to external magnetic fields
S MCQ1803 -AEC1	±5, ±10, ±20, ±30, ±40, ±50	5V	2.5%	-40 to +150	100	2200	0.9	SOIC-8	AEC-Q100, coreless, analog output, immune to external magnetic fields

POSITION SENSOR MAGNETS

Part Number	Magnetization	Geometry	Material	OD (mm)	ID (mm)	Height (mm)	Air Gap Min (mm)	Air Gap Max (mm)	Radial Tolerance (mm)	Notes
MAG10-2C-30.25	Diametrical	Cylinder	NdFeB, Grade N35SH	3	-	2.5	0	2	0.1	-
MAG10-2C-40.25	Diametrical	Cylinder	NdFeB, Grade N35SH	4	-	2.5	0	2.6	0.2	Standard-size, cost-effective
MAG10-2C-50.25	Diametrical	Cylinder	NdFeB, Grade N35SH	5	-	2.5	0	3.1	0.2	Standard-size, cost-effective
MAG10-2C-60.25	Diametrical	Cylinder	NdFeB, Grade N35SH	6	-	2.5	0	3.6	0.3	-
MAG10-2C-80.25	Diametrical	Cylinder	NdFeB, Grade N35SH	8	-	2.5	0	4.5	0.4	-
MAG10-2R-50.12.25	Diametrical	Ring	NdFeB, Grade N35SH	5	1.25	2.5	1	1.4	0.4	Accurate application
MAG10-2R-60.15.25	Diametrical	Ring	NdFeB, Grade N35SH	6	1.5	2.5	1.3	1.6	0.6	Accurate application
MAG10-2R-80.20.25	Diametrical	Ring	NdFeB, Grade N35SH	8	2	2.5	2	2.5	0.8	Accurate application
MAG10-2B-40.25	Axial	Half-Cylinder	NdFeB, Grade N35SH	4	-	2.5	0	2.1	<0.1	Low field emission
MAG10-2B-50.25	Axial	Half-Cylinder	NdFeB, Grade N35SH	5	-	2.5	0	2.7	<0.1	Low field emission
MAG10-2B-60.25	Axial	Half-Cylinder	NdFeB, Grade N35SH	6	-	2.5	0	3.2	<0.1	Low field emission
MAG10-2B-80.25	Axial	Half-Cylinder	NdFeB, Grade N35SH	8	-	2.5	0	4.2	0.1	Low field emission

N - New Product **S** - Sampling Product

MAGALPHA SERIES

Part Number	Resolution	Interface	Supply Voltage (V)	Supply Current (mA)	Sensing Range (mT)	Cutoff Frequency (Hz)	Latency at Constant Speed (μ s)	Temperature Range ($^{\circ}$ C)	Package	Notes
MA102	12-bit	SPI, UVW	3.3V	11.7	30+ (No Upper Limit)	390	8	-40 to +125	QFN-16 (3x3)	Motor commutation angle sensor, UVW multi-pole pair, differential outputs
MA302	12-bit	SPI, UVW, ABZ	3.3V	11.7	30+ (No Upper Limit)	390	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor, ABZ & UVW incremental outputs
MA310	12-bit	SPI, UVW, ABZ	3.3V	11.7	15+ (No Upper Limit)	93	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor, ABZ & UVW incremental outputs
MA330	9-bit to 14-bit	SPI, UVW, ABZ	3.3V	11.7	30+ (No Upper Limit)	23 to 6k	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor, ABZ & UVW incremental outputs
S MA600	11-bit to 14-bit	SPI, ABZ, UVW, SSI, PWM	3.3V	8	20 to 100	27k	1	-40 to +125	QFN-16 (3x3)	High-resolution, Low INL, high bandwidth
MA702	12-bit	SPI, SSI, PWM, ABZ	3.3V	11.7	30+ (No Upper Limit)	390	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor; ABZ, SSI, and PWM outputs
MA704	10-bit	SPI, SSI, PWM, ABZ	3.3V	11.7	30+ (No Upper Limit)	2970	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor; ABZ, SSI, and PWM outputs
MA710	12-bit	SPI, SSI, PWM, ABZ	3.3V	11.7	15+ (No Upper Limit)	93	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor; ABZ, SSI, and PWM outputs
MA730	14-bit	SPI, SSI, PWM, ABZ	3.3V	11.7	40+ (No Upper Limit)	23	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor; ABZ, SSI, and PWM outputs
MA732	10-bit to 14-bit	SPI, SSI, PWM, ABZ	3.3V	11.7	40	23 to 6k	8	-40 to +125	QFN-16 (3x3)	Contactless angle sensor; ABZ, SSI, and PWM outputs
N MA734	8-bit to 12.5-bit	SPI	3.3V	11	30+ (No Upper Limit)	95 to 95k	3	-40 to +125	QFN-16 (3x3)	Contactless angle sensor, lowest latency
N MA780	8-bit to 12-bit	SPI	3.3V	0.5uA to 10mA	30+ (No Upper Limit)	39 to 160k	4 to 4000	-40 to +125	QFN-16 (3x3)	Contactless low-power angle sensor, integrated wake-up and IRQ
N MA782	8-bit to 12-bit	SPI	3.3V	0.5uA to 10mA	30+ (No Upper Limit)	5 to 160k	4 to 4000	-40 to +125	QFN-14 (2x2)	Contactless low-power angle sensor, integrated wake-up and IRQ
MA800	8-bit	SPI, SSI	3.3V	11.7	30+ (No Upper Limit)	90	4000	-40 to +125	QFN-16 (3x3)	Contactless angle sensor, SSI output, push-button function
MA820	8-bit	SPI, ABZ	3.3V	11.7	30+ (No Upper Limit)	90	4000	-40 to +125	QFN-16 (3x3)	Contactless angle sensor, ABZ output, push-button function
MA850	8-bit	SPI, PWM	3.3V	11.7	30+ (No Upper Limit)	90	4000	-40 to +125	QFN-16 (3x3)	Contactless angle sensor, PWM output, push-button function
N MAQ430	12-bit	SPI, UVW, ABZ	3.3V	11.7	30+ (No Upper Limit)	390	8	-40 to +150	QFN-16 (3x3)	Automotive angle sensor, wettable flanks
N MAQ470	12-bit	SPI, SSI, PWM, ABZ	3.3V	11.7	30+ (No Upper Limit)	390	8	-40 to +150	QFN-16 (3x3)	Automotive angle sensor, wettable flanks
N MAQ473	9-bit to 14-bit	SPI, SSI, PWM, ABZ	3.3V	12	30+ (No Upper Limit)	23 to 6k	8	-40 to +150	QFN-16 (3x3)	Automotive angle sensor, wettable flanks, programmable cutoff frequency

N - New Product **S** - Sampling Product

ABOUT MONOLITHIC POWER SYSTEMS

Who we are

We are creative thinkers. We break boundaries. We take technology to new levels. As a leading international semiconductor company, Monolithic Power Systems (MPS) creates cutting-edge solutions to improve the quality of life with green, easy-to-use products.

What we do

We make power design fun! With our innovative proprietary technology processes, we thrive on re-imagining and redefining the possibilities of high-performance power solutions in industrial applications, telecom infrastructures, cloud computing, automotive, and consumer applications.

Where we come from

It started with a vision. Michael Hsing, pioneering engineer and CEO, founded Monolithic Power Systems, Inc. in 1997 with the belief that an entire power system could be integrated onto a single chip. Under his leadership, MPS has succeeded not only in developing a monolithic power module that truly integrates an entire power system in a single package, but also it continues to defy industry expectations with its patented groundbreaking technologies.

Our values

We cultivate creativity.

As a company, we believe in creating an environment that encourages and challenges our employees to collaborate and think outside the box to excel beyond their preconceived capabilities.

We do not accept the status quo.

We do not believe in limitations. It is not about what is, but what can be. Possibilities are endless at MPS.

We are passionate about sustainability.

It's about the future. From materials to finances, we are committed to conservation. We will not tolerate waste in an effort to improve and preserve the quality of life.

We are committed to providing innovative products to our customers.

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